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LOESS IN THE WISCONSIN DRIFT FORMATION.

LOESS has long been known to cover the glacial drift of the earlier ice epochs at various points, especially along the water courses of the western portion of the Mississippi basin, and to have more or less extensive development in like relation to valleys in extra-glacial territory both west and south of the drift. It also occurs, especially along the Mississippi and its tributaries, in the driftless area which lies in Wisconsin, Illinois, Iowa, and Minnesota.

In addition to its occurrence at the surface over the older drift sheets, loess is known to occur between beds of till outside the area covered by the ice of the Wisconsin epoch. In some places the surface of this buried loess is marked by a soil, often of considerable thickness. These facts show that there are at least two sheets of loess connected with the earlier sheets of drift. The sheet of loess which overlies the Iowan drift often terminates abruptly, as a surface mantle, at the edge of the Wisconsin formation, but frequently passes beneath it. Outside the drift-covered country also there are, in some places, two distinct beds of loess, the one above the other.¹ The surface of the lower is often marked by a well-developed soil, and furthermore shows, by its color and chemical condition, that it was long exposed before the overlying mantle was deposited upon it.

The stratigraphical relations of the loess and drift, especially when taken in connection with other considerations, seem to point clearly to the conclusion that the loess had an intimate connection with the drift in origin, and that there were at least two epochs of loess deposition later than the first, and earlier than the last, glacial epoch. The uppermost bed of extra-glacial loess, where two are developed, seems to be capable of definite

¹ Geological Survey of Arkansas, Ann. Rep. 1889, Vol. II, p. 233.

correlation with that which overlies much of the drift of the Kansan and Iowan epochs, while the lower is presumably the equivalent of some or all the loess beneath the Iowan and above the Kansan drift.

Heretofore loess has not been known to occur in or above the drift of the Wisconsin epoch; but during the past summer it has been found in connection with this formation at several points in Wisconsin, namely, near Green Lake, Devils Lake, and Ablemans.

Loess near Green Lake.—Loess occurs in at least two localities near Green Lake, in Green Lake county. One of these points is about two miles northeast of the village of Dartford in the S. W. $\frac{1}{4}$ of Sec. 10 (Tp. 16, R. 13 E.), where the loess is worked as molding sand for brass foundries. The loess here was not seen to contain shells or concretions, and is calcareous only at its base, and there but slightly. Its texture is fairly normal. It is exposed to the depth of eight or ten feet. The loess at this point is between 150 and 200 feet above Green Lake, and near the crest of one of the many high ridges of the region, the summits of which represent an old base plain. Its substratum is till of the Wisconsin formation.

The other point where loess is found is at the west end of the lake in Sec. 4 (Tp. 15, R. 12 E.). The loess here is at a lower level, and on a slope which faces the lake. As in the other case, it overlies the drift of the Wisconsin formation. The loess at this second locality is of greater thickness than at the first, and is normal in texture, color, structure, and composition. It is calcareous, and has the roughly columnar structure which frequently characterizes loess exposed in vertical faces, and contains both the common types of gastropod shells, and calcareous concretions, though neither is plentiful. Its character is in every way such as to allow of no doubt of its being normal loess. Near its base it is interstratified with gravel.

The loess in the vicinity of Green Lake is of special interest, not only because of its association with the deposits of the last

glacial epoch, but also because its relations show, in at least one of the two localities, that it is not the work of wind.

Super-till loam about Green Lake.—All about Green Lake it is a striking fact that the till, and indeed the drift in general, is covered by a layer of loam two to five feet thick, which is sufficiently different from the underlying drift to attract attention. It varies from a moderately stiff clay on the one hand, to a rather sandy loam on the other. It is generally heavier than its substratum, though influenced to some extent by it. Where it overlies stratified drift, it is on the whole less clayey than where it overlies till. It is sometimes altogether free from stony material, though this is not the rule. The absence of stony material is more likely to be the fact where the loam is thick than where it is thin, and where it overlies stratified drift, than where it overlies unstratified. The stony content of the loam may be either coarse or fine. If it contain boulders, as it sometimes does, they are in all cases, so far as seen, of a somewhat distant origin. Among the drift boulders of the region diabase predominates, and every boulder seen in the loam was of this type. The boulders of the loam do not differ in shape from the boulders of the same sort in the body of the drift. On the other hand, where the loam contains small stones they are in almost all cases of chert such as might have come from the local rock, especially the Lower Magnesian limestone; but in small bits it is not always possible to distinguish Lower Magnesian limestone chert from chert of other formations. The cherts are almost uniformly sharply angular. The stony matter both of the boulder type and of the smaller pieces is more likely to occur at or near the base of the loam, than at or near its top. Occasionally there is an aggregation of small stones at the junction of the till and loam. So well developed and so persistent is this loam that the surface of whole fields and even farms is without a trace of boulders, even where the till is notably bouldery.

There seems to be no special rule concerning the topographic distribution of the loam, further than that it is generally most

apparent on approximately level surfaces, and that it is least likely to be present on steep slopes. In general it does not appear to be stratified, though where it is thick it is occasionally marked more or less distinctly, with dark and light bands in an essentially horizontal position. This variation in color is probably the result of chemical changes since its deposition, brought about by the concentration of coloring matter along definite horizontal lines. The concentration along these definite plains probably means some variation in texture along these plains, and this probably points to stratification.

As seen in section, the contact of the loam above with the till below is usually irregular, but often sharply marked. Both the regularity and the distinctness of the contact are more striking between the loam and stratified drift than between the loam and till.

Where the loam overlying till attains a thickness of as much as four or five feet the lower portion very commonly approaches loess in character. Where the loam is thin, say two or three feet thick only, it does not resemble loess, though it is not unlike the uppermost two or three feet of clay-loam which overlies loess in regions where the latter has its more clayey and less normal development.

The suggestion of connection between the loam and loess was given added force by finding loess at the two points mentioned, in just such situations and relations as that in which the loam commonly occurs.

Loess at Devils Lake.—East of the south end of Devils Lake fresh railway cuts reveal the presence of loess on the terminal moraine of the Wisconsin epoch. The crest of the moraine along the line of the railway at this point is, according to the topographic map, between 60 and 80 feet above the lake. The loess may be seen on both the inner and outer slopes of the moraine, but does not cover its summit, failing to reach it on either side by about ten feet.

While some of the loess here is thoroughly typical, it locally grades, either horizontally or vertically, into clay which is very

unlike loess. It is sometimes capped by several feet of heavy clay, which is clearly not the product of loam-weathering. Calcareous concretions occur but rarely, as also those of iron oxide. Shells were not seen. The loess, and especially the associated and genetically equivalent clay, contains an occasional stone of considerable size. The loess, and the clay which goes with it, have a maximum thickness of not less than fifteen feet.

There seems to be adequate reason for believing that the loess on the outside of the moraine (toward the lake), was accumulated in the expanded lake which occupied the site of the present lake and its surroundings at the time of ice occupancy. There is independent evidence that the lake stood at least sixty-five feet above its present level. This evidence is found in the presence of what appear to be berg-floated boulders, up to this height about the borders of the depression (then a bay) at the southwest corner of the lake.

The loess on the inner slope of the moraine doubtless settled out of water which stood there after the ice had withdrawn a short distance to the east.

Loess at Ablemans.—Ablemans is about eight miles west of the moraine of the Wisconsin epoch, and in an area not overspread by the ice of any earlier epoch. Here at the extensive sandstone quarries, there is a fine exposure of loess not less than twenty feet in thickness. It occurs at a rather low altitude, and in such topographic relations as to bring it into unmistakable connection with the broad lacustrine (now terrace) flat which occupies the valley of the Baraboo, from Baraboo to Ablemans. The exposure is in a ravine, tributary to the Baraboo, and but a few rods from it. The lacustrine flat with which this loess is to be correlated is generally made up, superficially at least, of laminated calcareous clay, very unlike loess. It is to be especially noted that the loess at Ablemans does not occur next the moraine, but eight miles away in a small tributary ravine, the head of which did not receive glacial drainage, and that much finer deposits (clay) occur in the main valley between the loess and the moraine where the water was discharged from the ice

to the lake. The loess is here rich in calcareous concretions, and in gastropod shells of the types which abound in the loess. It also possesses the normal loess texture and structure. Indeed much of it is not wanting in a single distinctive loess characteristic. Bones of small mammals, as yet unidentified, were found at this point, at least ten feet below the top of the loess, and in such relations as to make it certain that the loess had not been disturbed or the bones introduced since the deposition of the formation. The loess here lies against a steep slope of sandstone and quartzite, and occasionally contains fragments of each.

A few rods away, at the same, or approximately the same level, an exposure in an isolated remnant of the terrace shows it to be made up of sand interbedded with loam which approaches loess in texture. The sand and loam are distinctly stratified and the stratification appears to be the work of water. The sand and loam at this exposure do not lie against a rock slope and no stones or pebbles were found in it.

The occurrence of loess at Ablemans is of special interest because it connects itself with the deposits of the lake which formerly occupied the valley of the Baraboo above the city of the same name. The lake was called into existence because the ice blocked the eastward drainage of the valley. It was maintained for a short time after the ice retired by the moraine dam which it left just above the City of Baraboo. Its position in a ravine through which glacial drainage did not flow, is also of significance.

The loess at Devil's Lake and at Ablemans, like that in the vicinity of Green Lake, was certainly deposited by water, and by water associated with the ice of the last glacial epoch. With the loess of Ablemans is to be correlated the clay in the valley of the Baraboo exposed at various points above the city, and the loams and clays, some of which are very loess-like, in the valleys of Seeley's and Narrow's creeks south of the Baraboo. The loam at Logansville in one of these valleys was seen many years ago to contain shells, and to be in other ways, somewhat loess-

like. At this point (Logansville) it is distinctly stratified, in places at least, and constitutes, or at any rate covers, the valley flat.

Loess-like loam about Baraboo.—In addition to the distinct development of loess at Devil's Lake, the surface of the drift about Baraboo is often marked by loam no less distinct than that about Green Lake. The surface loam does not seem to be restricted to the surface of the drift, but affects the extra-glacial surface as well. Even the high quartzite ridges seem to have a capping of it, though it cannot be affirmed that the loam (or clay) on these ridges is the equivalent of that over the drift.

The "east bluff" (the quartzite bluff east of the lake), 1560 feet above the sea level, and 800 feet above the valley of the Wisconsin five miles to the south, has a goodly development of clay-loam (five or six feet) upon it. This is exposed in but few places, but the sturdy character of the forest shows that there must be some soil other than that which could have arisen from the decomposition of the quartzite. At the spot where the problematical gravel heretofore described occurs¹ the gravel overlying the quartzite is covered by five to six feet of nearly stoneless clay loam. Its aspect is such as to suggest its genetic connection with the loess. This loam, or something very like it, whatever its origin, is widespread. Whatever is true of the extra-glacial surface loams, that which overlies the drift about Baraboo seems to belong with that which overlies the drift at Green Lake, and which so frequently grades toward normal loess and sometimes assumes the character typical of that formation. I now believe it to be the equivalent of the stoneless, or well nigh stoneless, mantle of clay which occurs at some points about Madison, and which I was formerly inclined to regard as wind-blown dust accumulated on the ice and deposited in the final melting.² In the adequacy of this suggestion I

¹ JOUR. OF GEOL., Vol. III, p. 655.

² Proc. Am. Ass. for Adv. of Sci. 1893, p. 180. See also Ann. Report of the State Geologist of N. J., 1893, pp. 211-24.

have less confidence than formerly. The phenomenon to be explained is widespread and may involve a much bolder hypothesis.

Loess-like loam near Camp Douglas, Wis.—In the vicinity of Camp Douglas, Wis., there is a considerable development of loess-like loam which is probably genetically connected with loess, though lithologically not identical with the normal phase of that formation. Nevertheless it frequently approaches loess very closely in physical character.

Like Ablemans, Camp Douglas is outside the glaciated area. The station itself is about twenty miles west of the Wisconsin River, on a base-level plain of somewhat extensive development. About the Camp the general plain is marked by occasional notable elevations of sandstone rising up about 200 feet above the flat. To the west there is a dissected plain at a corresponding elevation. Above this plain, which represents a base-plain older than that already referred to, rise other elevations something like 200 feet higher. These are remnants of a base-plain developed during a still earlier cycle of erosion. The dissected plain which stands 200 feet or so above the railway at Camp Douglas is of sandstone, but it is mantled by a clay-loam, to which the sandstone could hardly have given rise. It is rarely exposed, but about four miles northwest of Camp Douglas a section may be seen which shows that, in its general features, it is very similar to loess; that, indeed, it is indistinguishable from some of the less normal phases of that formation. The exposure is at the head of a ravine cut into the upper plain referred to, and from its position and relations there can be no doubt of its continuity and genetic unity with the clay-loam mantle which overspreads the plain.

It is possible that the lowest plain about Camp Douglas was flooded by glacial water during the Wisconsin epoch of the glacial period. It is tolerably certain that the higher plain was not so covered. This loess-like loam is therefore believed to be connected, not with the Wisconsin formation, but with one of

the earlier epochs, though which one, it is, in the light of present knowledge, impossible to say.

Whether loess or anything genetically equivalent to it extends over the elevations which rise above the dissected plain has not yet been determined. The remnants of this earlier and higher plain, so far as visited, were limited in extent, and any loam which might once have covered them would be likely to have disappeared. It is to be borne in mind, however, that these elevations are lower than the Baraboo quartzite ranges, over which clay loam has been deposited in recent time.

There can be little doubt that loam, sometimes clayey (especially over limestone), and sometimes sandy (especially over sandstone), but in all probability genetically connected with the loess, is widespread in the driftless area.

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